What is the mechanism effect that links social support to coping and psychological outcome within individuals affected by prostate cancer? Real time data collection using mobile technology.

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Purpose: Unmet support needs are prevalent in men affected by prostate cancer. Moreover, little is known about the optimal type of social support, or its mechanism effect between coping and emotional outcome in men affected by this disease to identify areas for clinical intervention. This study aimed to empirically test the propositions of social support theory in "real time" within individual men living with and beyond prostate cancer.

Methods: Purposeful sub-sample from a larger prospective longitudinal study of prostate cancer survivors, took part in real time data collection using mobile technology. Self-reports were collected for 31 days prompted by an audio alarm 3 times per day (a total of 93 data entries) for each of the 12 case studies. Electronic data were analysed using time series analysis.

Results: Majority of response rates were >90%. Men reported a lack of satisfaction with their support over time. Testing the propositions of social support theory "within individuals" over time demonstrated different results for main effect, moderation and mediation pathways that linked coping and social support to emotional outcome. For two men, negative effects of social support were identified. For six men the propositions of social support theory did not hold considering their within-person data.

Conclusion: This innovative study is one of the first, to demonstrate the acceptability of e-health technology in an aging population of men affected by prostate cancer. Collectively, the case series provided mixed support for the propositions of social support theory, and demonstrates that "one size does not fit all".

Introduction

Prostate cancer is a major health burden in Europe (Jemal et al., 2011). The disease and its treatments have the potential to cause substantial short- and long-term problems for men affected by prostate cancer (Davis et al., 2014). The delicate nature of treatments mean that men with prostate cancer often face a host of difficulties which can negatively affect Health-Related Quality of Life (HRQoL) (van Tol-Geerdink et al., 2013), including physical and psychological problems (Cockle-Hearne et al., 2013; Ream et al., 2008). Toxicities associated with prostate cancer treatments include: urinary (urgency, frequency, incontinence) (Zelefsky et al., 2008), bowel (rectal bleeding, urgency in defecation, diarrhoea, and faecal leakage) (Fransson et al., 2006) and sexual dysfunction (impotence, loss of libido) (Shikanov et al., 2008). Other physical symptoms associated with therapies include: fatigue, weight gain, osteopenia, anaemia, muscle atrophy, gynaecomastia, and hot flushes, and psychological problems including anxiety, depression and loss of cognitive function (Carter et al., 2011). Due to increasing survival rates (Jemal et al., 2011) the number of men dealing with the aftermath consequences of prostate cancer are set to rise, currently 250,000 men in the UK alone (Prostate Cancer UK, 2014).

For many patients and family members, a diagnosis of prostate cancer can lead to many ambiguities, such as whether the cancer will recur, whether the cancer will prove fatal, or will it lead to permanent physical problems and disability. For these reasons, and for many others, the experience of prostate cancer is uniquely stressful; and social support has been demonstrated to be beneficial in coping with prostate cancer's associated stressors (Roberts et al., 2006). Social support for many individuals is an intuitive term that is used to describe help that is received from others in a difficult situation. There is a substantial body of social support literature, as yet there is not a single consensus on the definition of social support (Hupcey, 1998), but an important distinction is that social support is a multi-faceted construct (Paterson et al., 2013). That is to say, social support can be measured as perceived social support and received social support (Cohen et al., 2000; Schwarzer et al., 2003). Perceived social support is a construct that is used to describe social support anticipated prospectively at a time of need sometime in the future (Procidano and Heller, 1983), whereas received social support is based upon retrospective accounts of received social support (Barrera et al., 1981). Perceived and received social support constructs can be further distinguished by the following types of social support: emotional, informational, and instrumental (Cohen et al., 2000). Social support is associated with improved HRQoL for cancer survivors (Helgeson, 2003) and the mechanisms underlying such links can be explained by the propositions of social support theory.

There are two dominant theoretical frameworks that link social support to improved physical and mental well-being: the Main Effects Model and the Stress Buffering Model (Cohen and McKay, 1984). According to the main effects model, people with high social support (perceived or received social support) have better physical and mental health compared to those with low social support, regardless of the levels of stress (Cohen and McKay, 1984). The relationship between social support and HRQoL is believed to be linear for the main effects model (Helgeson, 2003). Whereas, the stress buffering model states that social support (perceived and received social support resources) is associated with improved physical and mental health only when individuals are exposed to stressful conditions (Cohen et al., 2000). Thus, under conditions of high stress, social support is believed to act as a buffer (moderator variable) against the adverse effects of that stressor. The term "buffering" is used because it is believed, according to buffering model, that social support lessens the pathogenic effects of a stressor, for example, a cancer diagnosis or living with sexual dysfunction. The stress buffering hypothesis states that coping performances are enhanced when social support (Cohen et al., 2000) is high, and is very closely related to Lazarus and Folkman's (1984) theory on stress and coping.

Coping can generally be defined as cognitive and/or behavioural attempts to manage situations that are appraised as stressful to an individual (Roesch et al., 2005). Coping has been defined as "constantly changing cognitive and behavioural efforts to manage specific external or internal demands that are appraised as taxing or exceeding the resources of a person" (Lazarus and Folkman, 1984). The transactional process of stress and coping theory dominates social support research (Lakey and Orehek, 2011) and details the central importance of social support on improving emotional outcome for prostate cancer survivors (Zhou et al., 2010a; Zhou et al., 2010b). The propositions of social support theory suggest that social support may operate through main and moderation effects, but existing social support theoretical models do not explicitly detail the possibility of mediation effects, i.e. that coping is related to emotional outcome because of social support, see figure 1.

(Please insert figure 1 here)

The importance of social support as a resource for people affected by cancer is not a new concept, but specifically, prostate cancer survivors have reported a lack of support for their unmet physical and psychological problems (Cockle-Hearne et al., 2013; Paterson et al., 2015; Ream et al., 2008). Therefore, understanding the mechanism effect of how coping and social support operate on

emotional outcome over time has the potential to help to identify men who are at high risk of inadequate support provision and suggest directions for intervention (Paterson et al., 2013). Moreover, further work is needed to understand and assess whether the severity of prostate cancer stage (localised, locally advanced and metastatic) affects the mechanism effect of social support.

To date, literature examining the mechanism effect that links coping, social support and emotional outcome in men affected by prostate cancer is restricted to aggregate group level effects, i.e. between-person effects (Mehnert et al., 2010; Paterson et al., 2013; Paterson et al., 2014, Zhou et al., 2010a; Zhou et al., 2010b), and has neglected the importance of *within-person* experience and change over time. Therefore, existing literature has primarily employed between-subject designs, which only accounts for the variability between study participants. Many psychological theories, including the propositions of social support theory (Cohen and McKay, 1984; Cohen et al., 2000), describes the process that occurs within individuals and therefore, existing evidence to date may not adequately test the underlying within-person mechanisms proposed by social support theory.

Case-based (n of 1) time series studies (Molenaar, 2004) can form the *pre-clinical and theoretical modelling* stages of the Medical Research Council's framework for complex interventions (Craig et al., 2008). The first step in designing a complex intervention is to establish the theoretical basis that suggests that a future intervention may have the effect(s) expected. Therefore, case-based time series methodology is low-cost and has the potential to be very effective in facilitating the early development stages of interventions. Moreover, a further advantage to using this approach is that the electronic diary data are collected in real time, which is date and time stamped (at the time of data entry), and therefore minimises the risk of introducing retrospective memory recall (Stone et al., 2004; Stone et al., 2003; Stone and Shiffman, 2002). Empirically, testing within-person change over time has the potential to demonstrate the optimum types of social support that influence emotional outcome for men living with and beyond prostate cancer. Thus, applying theoretical constructs using a within-person design is likely to enrich and enhance tailored interventions focussed at the individual level of change (Borckardt et al., 2008). Therefore, this study aimed to address the following research question: does social support (perceived, received and satisfaction level) moderate/mediate the relationship between coping and negative affect within individuals affected by prostate cancer?

Methods

After ethical approval was granted (10/S1402/7) this study recruited participants from two teaching hospitals in the UK using the following inclusion criteria: confirmed diagnosis of prostate cancer (PC) all stages and treatments, before radical PC treatment commenced, ability to read and write English, and able to give informed consent. Exclusion criteria were those individuals unable to meet the inclusion criteria or those patients identified by their clinical care team to be physically or psychologically unfit to take part in the study. Recruitment took place at 2 hospital out-patient settings, and demographic and clinical data were collected. Participants were asked to complete validated questionnaires at baseline (before radical treatment) and at six month follow-up (but these data are published elsewhere Paterson et al., 2014). A sub-sample of men (n=12) were asked to complete an electronic behavioural diary which captured real-time patient reported outcome measures.

A small handheld PDA with diary software was used for each of the 12 study participants. The electronic behavioural diary (Dell Axim X51) was supported by Pocket Interview software (Morrison et al., 2009) and data was encrypted using the RC4 cipter (Morrison et al., 2009). This type of methodology has not been applied to prostate cancer participants before, therefore the research team under took essential pilot work and convened a research steering group which included men with prostate cancer, clinicians and the research team. Service user's feedback was essential in the design, scheduling and timing of data collection in this study. The pilot was a two-phase process; "phase 1" involved 11 electronic diary pilots among colleagues and acquaintances, with "phase 2" consisting of 6 electronic diary pilots directly involving men with prostate cancer. The pilot work informed the development of the electronic behavioural diary, ensured service user involvement in the design, its acceptability and face validity, whilst providing an opportunity to address any technical issues.

Each participant collected data for 1 month prompted by audio alarm to complete the diary at 3 pre-determined intervals per day (totalling 93 data points). In addition, the participants could complete an incident entry at any time throughout the 1-month period. The participants were instructed verbally (by CP) on the diary usage and were given written instructions. A battery charger was provided to enable the participants to recharge the electronic behavioural diary battery every few days over the course of the month. Participants were contacted by telephone 24 hours (by CP) after starting the electronic diary, to answer any questions and offer additional instruction, if required. At the end of the 1-month period, the researcher met again with the participant to collect the electronic behavioural diary and retrieve the stored data on the device.

Purposive Sampling Framework

Seventy-four men consented to take part in the prospective longitudinal study (Paterson et al., 2014) and of those 74 men, 62 (83.8%) consented to take part in the electronic diary data collection. To address the research question we used a sampling framework to identify the 12 study participants, a suitable sample size for this type of study (Hobb et al., 2013) defined by: cancer stage (localised, locally advanced, metastatic), having a partner or not, and self-reports of social support using the Berlin Social Support Scale (BSSS) as part of the larger longitudinal prospective study. The BSSS mean was found to be 3.2 (SD 0.6, [range 2.2 to 4.0]) and participants were recruited using 1 SD (3.8) above to indicate high social support and 1 SD (2.6) below to indicate low social support. The sampling framework criteria were important to assess the mechanism effect of social support based on severity of cancer stage, and level of social support. Study participants completed the electronic diary within 6 months of diagnosis.

Statistical Analysis

The electronic behavioural diary data were coded using XML coding and transferred into Microsoft Access (this formed part of the Pocket Interview software). Subsequently, the data were transferred to SPSS version 21.0. Data were examined for accuracy of data entry, missing values and univariate outliners, prior to the statistical tests the evaluations of the assumptions were checked (Tabachnick and Fidell, 2007). For case-based time series analysis, a minimum of 30-60 data points are needed (Borckardt et al., 2008), therefore this study collected 93 data points per participant to allow for any missing data.

Time series analysis was used because the study data consisted of sequential data points in successive order within individuals over time (Hobb et al., 2013). The data from the single-case studies has the potential to violate the assumption of independence in regression and correlation analysis (Borckardt et al., 2008) because all of the data points within a case study are from the same individual (not inpependent) . Therefore, using time series methods daily sequential data was examined for autocorrelation (serial dependency) using autocorrelograms produced in SPSS. If a significant autocorrelation was identified (indicating a violation of the assumption of independence), the data series was then subject to a pre-whitening procedure (Cromwell et al., 1994), which controlled or accounted for the autocorrelation and ensured the independence of the data points to enable inferential statistics to be used (Tabachnick and Fidell, 2007). The pre-whitening procedure involved examining the partial plots of autocorrelograms, and then creating a new lagged variable based on the number of lag displayed on the plot (Crane et al., 2003; Hobb et al., 2013; Tabachnick

and Fidell, 2007). In other words, a plot displaying first-order autocorrelation would require producing a new time series variable with a lag of 1, using the original variable. The second step in the pre-whitening procedure required linear regression. The new lagged variable (IV) was used to predict the original variable (non-lagged series) (DV). The unstandardsied residuals of the regression analysis was then the new pre-whitened variable (Crane et al., 2003; Hobb et al., 2013; Tabachnick and Fidell, 2007) and underwent a quality check to ensure that the presence of autocorrelation in the time series had been removed.

The independent variables were included in the moderation analyses guided by the theoretical framework (Cohen et al., 2000) see figure 1 to explicitly test the stress-buffering hypothesis. Variables were entered into the regression analyses if they had correlations between variables at the alpha level of $p < 0.05$ (Tabachnick and Fidell, 2007). The moderation analyses were undertaken using guidance from Aiken and West (1991); Frazier et al. (2004). The predictor variable (coping) and moderator variable (social support) were standardised, so that they had a mean of 0 and a standard deviation of 1. Standardising the variables makes it easier to plot significant moderation effects and reduces problems of multicollinearity (high correlations) among the variables in the regression equation (Aiken and West, 1991; Frazier et al., 2004). The product term was formed by multiplying the standardised predictor and standardised moderator variables together. The variables were then entered into hierarchical multiple regression analyses in specified blocks. The first step involved entering the standardised predictor and standardised moderator variable, and lastly, to include the product term in the model (Aiken and West, 1991; Frazier et al., 2004).

Guidance from Hayes (2009) was used to test for mediation effects of coping, social support and HRQoL, anxiety and depression. To test for mediation effected required performing 3 multiple regression analyses (Hayes, 2009). The first step was to establish that the predictor was significantly related to the outcome (if the result was significant, then the first step in mediation was met). The second step was to establish that the predictor and mediator variables were related. This was undertaken by a second regression analysis between the predictor (X) (predictor) on the mediator (M) (outcome) if significant, then the second condition for mediation holds. The last step was to test the outcome variable (Y) simultaneously on the mediator variable (M) and the predictor variable (X). If the mediator variable (M) was related to outcome variable (Y) then the third step for mediation had been met. Statistical significance was assessed at an alpha of $p < 0.05$.

Variables

The structure of the diary consisted of a standard entry, end-of-day entry and incident entry. The content of the diary questions were mapped to the constructs of the standardised questionnaires (used in the prospective longitudinal survey: coping, social support, and emotional outcome) (Cohen et al., 1983; Schulz and Schwarzer, 2003; Watson and Homewood, 2008; Zigmond and Snaith, 1983) and diary items were informed by expert comment from clinicians and prostate cancer patients (see Table 1 for overview measurements. Most question items were presented on the PDA using a visual analogue scale (VAS) from 0-100 scale.

EMOTIONAL OUTCOME: Positive and negative affect (Aaron et al., 2005, Affeck et al., 1998, Watson et al., 1988b) was assessed by asking the participants, "*How are you feeling just now? … tired, alert, happy, nervous, frustrated, sad, stressed, energetic, and angry"* using the scale "*not at all/extremely" (0-100)* for each state of affect. This spectrum enabled positive and negative states of affect to be captured.

COPING: The coping styles (fighting spirit, helpless/hopeless, anxious preoccupation, fatalistic, avoidance) were based upon the Mental Adjustment to Cancer Scale (Watson and Homewood, 2008, Watson et al., 1988a). Participants were asked to rate each of the following statements taken from the MAC scale: *"I tried to keep a positive attitude"* (positive attitude), "*I felt like giving up"* (helpless/hopeless), *"I felt problems with my health prevent me from planning ahead"* (anxious preoccupation), *"I felt that nothing I can do will make a difference"* (fatalistic), and *"I tried not to think about it"* (avoidance) using the response scale "*not at all/always" (0-100)* to rate each of the coping styles statements. These items were chosen based on comment and collective agreement from the research steering group that included service users.

SOCIAL SUPPORT: Participants were asked about perceived, received and satisfaction with social support. The questionnaire items were based on a multi-dimensional assessment of social support (Schulz and Schwarzer, 2003) and underpinned by the theoretical model (Cohen et al., 2000). Participants were asked, *"How much support have you had in the last few hours?"* (received social support), rating the following four scales *"financial, emotional, informational and practical",* with all scales anchored by the endpoints, *"none/a lot" on* a 0-100 scale. Perceived social support was measured by asking *"Do you have enough available support from people around you?"* and rated by offering the same scales as received social support. Participants were also asked *"Have you sought out support in the last few hours?"* and used a check box to indicate *"yes or no".*

Results

Seventy-four men consented to take part in the larger prospective longitudinal study and of those 74 men, 62 (83.8%) consented to take part in the N-of-1 study case-based time series studies.

(Please insert figure 2 here)

Unfortunately, participant 100/25's (in Figure.1) data were not recorded on the PDA throughout his one-month period of data collection due to a technical problem. Four men (Mr A, Mr B, Mr C and Mr D) had localised cancer, five men (Mr E, Mr F, Mr G, Mr H and Mr I) had locally advanced cancer, and two men (Mr J and Mr K) had metastatic cancer. The response rates for the diary data collection were very high; see table 1 for an overview of the response rates and demographic characteristics of the sample. Two participants had response rates greater than 80%, and nine participants demonstrated a response rate greater than 90%.

(Please insert table 1 here)

The case series of eleven men (Mr A to Mr K) identified that social support constructs displayed a certain degree of variance over time, and demonstrates that traditional instruments cannot accurately detail the intra-individual experience over time and the changes in social support provision, (see figure 1S in supplementary information). Importantly, all of these men (apart from Mr, A, Mr C and Mr F) reported a lack of satisfaction with their support over time.

Main, moderation and mediation

A summary of main, moderation and mediation effects across all of the eleven case studies are presented in table 2.

(Please insert table 2 here)

In relation to the sampling framework, no pattern of results are identified for main, moderation and mediation effects for social support with cancer stage, level of social support or co-morbidity. Moreover, no commonalities or differences are identified when comparing the clinical and demographic variables detailed table 1 alongside table 2 for the following: socio-economic status, level of education, employment status, age or co-morbidity. See table 3 for exemplar of mediation analyses between coping, social support and emotional outcome for Mr A (all other statistical analysis results are presented in the supplementary information section.) For six men no main, moderation or mediation effects were identified.

(Please insert table 3 here)

Discussion

The N-of-1 case series design using mobile technology was acceptable for these men, which was demonstrated by the very high response rates. Together the eleven case studies have provided mixed findings for the propositions of social support theories. Two men (Mr A and Mr H) provided support for the propositions of the main effects social support model (Cohen and McKay, 1984; Cohen et al., 2000) within-person design. For these men (Mr A and Mr H), perceived social support (perceived availability of social support at a time of need) was the most important social support construct that predicted emotional outcome. Furthermore, perceived social support was found to partially mediate the relationship between coping (positive and negative) and negative affect in both case studies (Mr A and Mr H). Meaning, these findings have identified a causal link between coping and emotional outcome because of perceived social support for these men at that stage in their illness and in the situations reported. Not only is this statistically relevant but clinically important because perceived social support could be a potential intervention target to optimise emotional outcome in future studies.

The stress buffering model (moderation effects) (Cohen and McKay, 1984; Cohen et al., 2000) was supported by three N-of-1 studies (Mr B, Mr C and Mr F) results presented in the supplementary information. Each of the three men differed in clinical characteristics and level of social support. These findings suggest that when men are coping with their illness they can experience negative affect when they have inadequate social support provision. This unique within-person assessment over time has demonstrated replication of this moderating effect for three case studies, but this finding was not replicated across the remaining 8 case studies. The majority of men reported a lack of satisfaction with social support over time as detailed in the time series plots. Additional work is needed to identify what types of support are most helpful to men and in what circumstances over the course of the prostate cancer journey (Paterson et al., 2013).

For two men (Mr B and Mr F) social support was predictive of higher negative affect, thus contradicting social support theory. For Mr B, received social support was a significant predictor of higher negative affect and, positive coping was associated with negative affect when received social support was high (see figure 2S in supplementary information). These findings support that not all provisions of support are helpful and this has been reported elsewhere (Zhou et al., 2010b). This is a paradoxical finding and does not support the main effects theoretical model or the stress buffering model. According to the social support theory (Cohen et al., 2000; Schwarzer et al., 2003), social support transactions are related to successful adaption and linked to improved health outcomes (Roberts et al., 2006). The negative consequences of social support identified in this case series are not new emergent findings, and are in keeping with findings that have demonstrated the negative

consequences of social support on health outcomes (Scholz et al., 2008; Schwarzer et al., 2006). Whereby, not all support is helpful and sometimes, inappropriate support is given at the wrong time.

For six men (Mr D, Mr E, Mr G, Mr I and Mr J and Mr K) the propositions of social support theory were not supported at that stage in their illness and in the reported situations. The six men had a range of cancer stages, treatments and level of social support, among additional demographic characteristics. The sampling framework criteria enabled the propositions of social support theory to be tested with individuals with high support, and in individuals with low support, and identified that this did not influence the mechanism effect of social support on emotional outcome.

Collectively, these findings suggest that social support intervention would not be appropriate for these (six) men, because the theorised process of social support is not empirically supported within individuals, and thus social support intervention might prove ineffective. Published social support intervention studies in men affected by prostate cancer (Carmack Taylor et al., 2006; Northouse et al., 2007; Zhang et al., 2007) report no statistically significant effect on improved HRQoL or emotional outcome, and therefore, the lack of intervention effect within such studies might be explained by the findings presented here. If the theorised mechanism of social support is not supported within individuals as identified in the current study, it is unlikely that social support intervention would be appropriate for such men.

The findings from this case series (Molenaar, 2004) have informed the theoretical modelling stage of the Medical Research Council's framework for complex interventions (Craig et al., 2008) and has identified possible heterogeneity of future social support intervention effects. These findings suggest that underpinning a future intervention study by the propositions of social support theory would not be suitable for all men, because this study has demonstrated that "one size does not fit all". This study has provided a unique insight into the individual experiences of men that minimised retrospective memory recall and reduced data fabrication. Time series analyses offer a powerful statistical method to explore relationships between theoretically related constructs. This is the first study to identify variability in social support constructs over time that are idiosyncratic to individuals and therefore, standardised retrospective social support measures may not be sensitive to detect variability within individuals over time.

This study has several limitations; first off, the sample was biased in favour of white Caucasian men and limits the transferability of the study findings. There is growing interest in real time data collection technologies in healthcare research, and policy drivers for tele-health, but to date no standardised instruments are available, and as a consequence measurement error is possible in the

interpretation of these findings. However, the strength to this study was that the measures used in this study were adapted from existing standardised instruments and expert patient and clinician comment. This study assessed men's experiences for a total of one month following radical treatment for prostate cancer and therefore, real time assessment of mens' experiences beyond this period is unknown. Despite these limitations, this innovative study is the first to date to demonstrate the value of n-of-1 designs as a theory testing tool in prostate cancer care.

Conclusion

Collectively, the findings from the eleven case studies have informed the theoretical modelling stage of the Medical Research Council's framework for complex interventions. The study has provided mixed support for the propositions for social support theory and it appears that one size does not fit all. Electronic data collection methods are feasible and acceptable to men with prostate cancer, and are considered beneficial for use in future research. The negative effects of social support for two men cannot be ignored, and completely contradicts social support propositions. Therefore, future research would be important to further test this innovative methodology, refine measurement instruments, and develop social support theory at the within-person level of change.

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Highlights

- This study has developed and refined our theoretical understanding of the psycho-social mechanisms that link coping, social support and psychological well-being in men affected by prostate cancer, and has contributed towards the first stage of the Medical Research Council's framework for complex interventions.
- This innovative study is one of the first to demonstrate the acceptability of e-health technology in an aging population of men affected by prostate cancer.
- Real time data collection moves far beyond traditional retrospective evaluations enabling a much clearer understanding of patient experience throughout the cancer journey.
- Collectively the findings provide mixed support for the propositions of social support theory, and demonstrates that "one size does not fit all".

Conflicts of Interest

None to Declare

Table 1 Measurement Items to test social support theory

Enquiry	Subscale and variables	Number of items
Standard Entry (3 times per day, for a total of 1 month (n=93)	**Negative affect*** (Aaron et al., 2005; Watson et al., 1988a) How do you feel just now? (0-100) Nervous, Frustrated, Sad, Angry, Stressed, Tired	6
	Positive affect* (Aaron et al., 2005; Watson et al., 1988a) How do you feel just now? (0-100) Alert, Happy, Energetic	3
	Positive coping* (Watson et al., 1988b; Watson and Homewood, 2008) Please rate each of the following statements which describes how you have coped in the past few hours with your self-care? (0-100) I tried to keep a positive attitude	1
	Negative coping* (Watson et al., 1988b; Watson and Homewood, 2008) Please rate each of the following statements which describes how you have coped in the past few hours with your self-care? (0-100) I felt like giving up, I felt problems with my health prevented me from planning ahead, I felt that nothing I can do will make a difference, I tried not to think about it	4
	Perceived social support* (Cohen et al., 2000; Schulz and Schwarzer, 2003) Do you have enough available support from people around you? (0-100) Financial, Emotional, Practical, Informational	4
	Received social support* (Cohen et al., 2000; Schulz and Schwarzer, 2003) How much support have you received in the past few hours? (0-100) Financial, Emotional, Practical, Informational	4
	Sought social support (Cohen et al., 2000; Schulz and Schwarzer, 2003) Have you sought out social support in the past few hours? (yes/no)	1

*Summary score used in the analysis.

Table 2 Electronic diary response rates

Participant and social support	Response rate	Cancer stage and treatment	Co-morbidity	Age	Education-highest qualification	Employment	Socio-economic (SIMD 1 most deprived – 5 least deprived)	Diary Schedule
Mr A Partner High support	94.6%	Localised prostate cancer AS	No	73	HNC	Retired	4	10am, 4pm, 10pm
Mr B Partner Low support	90.3%	Localised prostate cancer AS	No	61	BA	Employed	4	10am, 4pm, 10pm
Mr C Partner High support	87%	Localised prostate cancer LRP	No	51	No qualification	Employed	2	8am, 2pm, 8pm
Mr D Partner High support	97.7%	Localised prostate cancer LRP	No	59	Trade qualification	Retired	5	10am, 4pm, 10pm
Mr E Partner High support	97.9%	Locally advanced prostate cancer HT and EBRT	No	65	Trade qualification	Retired	4	10am, 4pm, 10pm
Mr F Partner High support	90.3%	Locally advanced prostate cancer HT and EBRT	No	57	Trade qualification	Employed	1	10am, 4pm, 10pm
Mr G Partner Low support	97.9%	Locally advanced prostate cancer HT and EBRT	Yes Asthma Hypertension Depression	64	HND	Retired	4	10am, 4pm, 10pm
Mr H No partner High support	97.8%	Locally advanced prostate cancer HT and EBRT	No	73	Trade qualification	Employed	4	9am, 3pm, 9pm
Mr I No partner Low support	81.7%	Locally advanced prostate cancer HT and EBRT	Yes Asthma Hypertension	73	Post graduate HND	Retired	4	9am, 3pm, 9pm
Mr J Partner Low support	94.6%	Metastatic disease HT	No	73	A levels	Retired	3	9am, 3pm, 9pm
Mr K Partner High support	91.3%	Metastatic disease HT	No	72	Trade qualification	Retired	5	10am, 4pm, 10pm

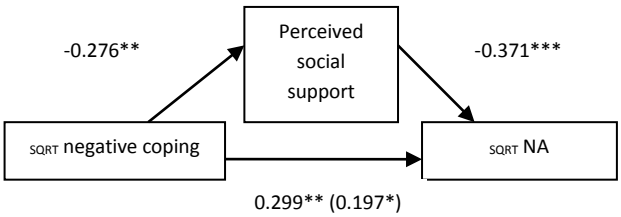
AS (Active surveillance), LRP (Laparoscopic radical prostatectomy), HT (Hormone therapy), EBRT (External beam radiotherapy)

Table 3 Summary of main, moderation and mediation effects across the eleven case studies

Sampling framework criteria)	Main effects	Moderation effects	Mediation effects
Mr A (localised cancer/high support)	Positive coping Negative coping Perceived social support	None	Yes – negative coping and negative affect is partially mediated by perceived social support. The relationship between positive coping and negative affect is partially mediated by perceived social support
Mr B (localised cancer/low support)	Positive coping Received social support	Yes – high positive coping is associated with high negative affect under conditions of high received social support.	None
Mr C (localised cancer/high support)	Positive coping Negative coping	Yes – low negative coping is associated with high negative affect under conditions of low received social support.	None
Mr D (localised cancer/high support)	None	None	None
Mr E (locally advanced cancer/high support)	None	None	None
Mr F (locally advanced cancer/high support)	Negative coping	Yes – High negative coping was associated with high negative affect under conditions of low received social support. High negative coping is associated with high negative affect under conditions of high perceived social support	None
Mr G (locally advanced cancer/low support)	None	None	None
Mr H (locally advanced cancer/high support)	Negative coping Positive coping Perceived social support	None	Yes- negative coping and negative affect partially mediated by perceived social support. Positive coping and negative affect is partially mediated by perceived social support.
Mr I (locally advanced cancer/low support)	None	None	None
Mr J (metastatic cancer/low support)	None	None	None
Mr K (metastatic cancer/high support)	None	None	None

Table 4 Exemplar mediation statistical analysis Mr A: Negative coping and negative affect partially mediated by perceived social support

Step and variable	B	SE B	β	R^2
Step 1 (path C)				
Constant	1.844	0.392		
Outcome: SQRT Negative affect				
Predictor: SQRT Negative coping	0.324**	0.111	0.299**	0.089
Step 2 (Path A)				
Constant	6.233	1.867		
Outcome: Perceived social support				
Predictor: SQRT Negative coping	-1.411**	0.531	-0.276**	0.076
Step 3 (path b and c')				
Constant	9.387	2.066		
Outcome: SQRT Negative affect				
Mediator: Perceived social support (path b)	-0.078***	0.021	-0.371***	
Predictor: SQRT Negative coping	0.213*	0.108	0.197*	0.216



Beta weights for the relationship between negative coping and NA partially mediated by perceived social support for Mr A.

The beta weights for SQRT negative coping and SQRT NA controlling for perceived social support are in the parentheses *P<0.05, **P<0.01, ***P<0.001

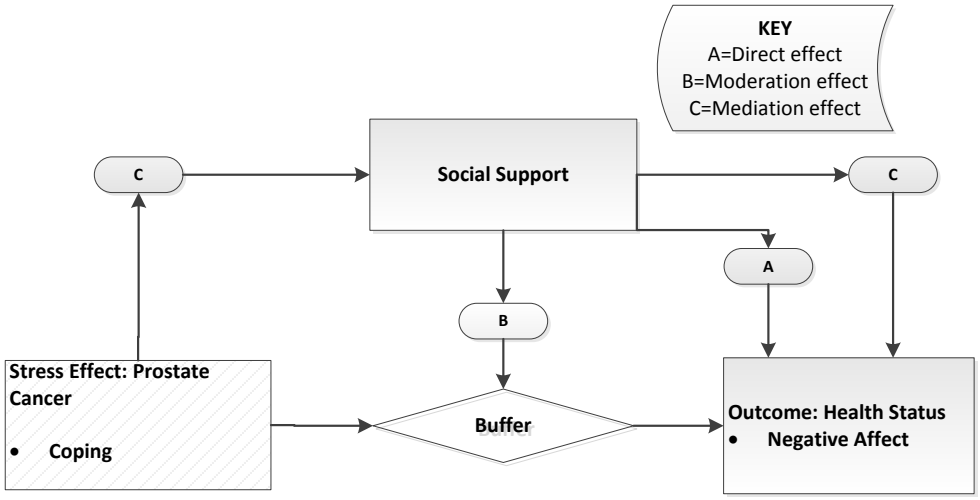


Figure 1 Social support theoretical model

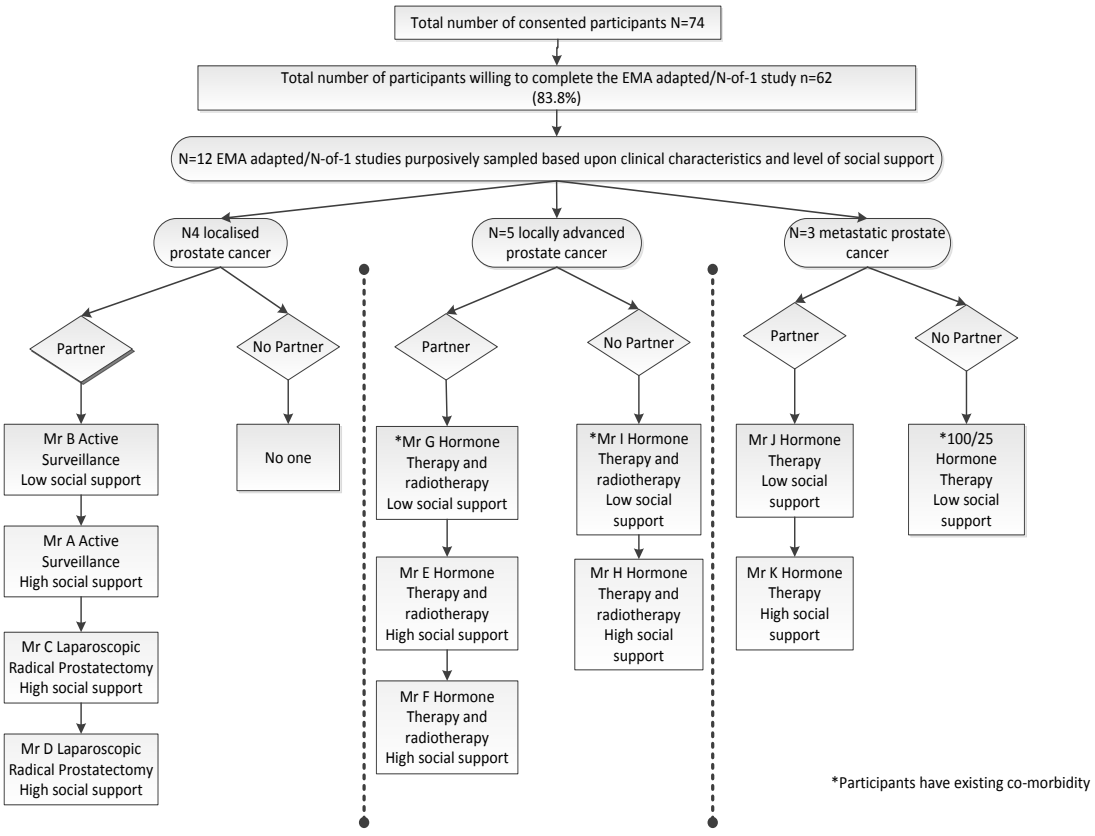
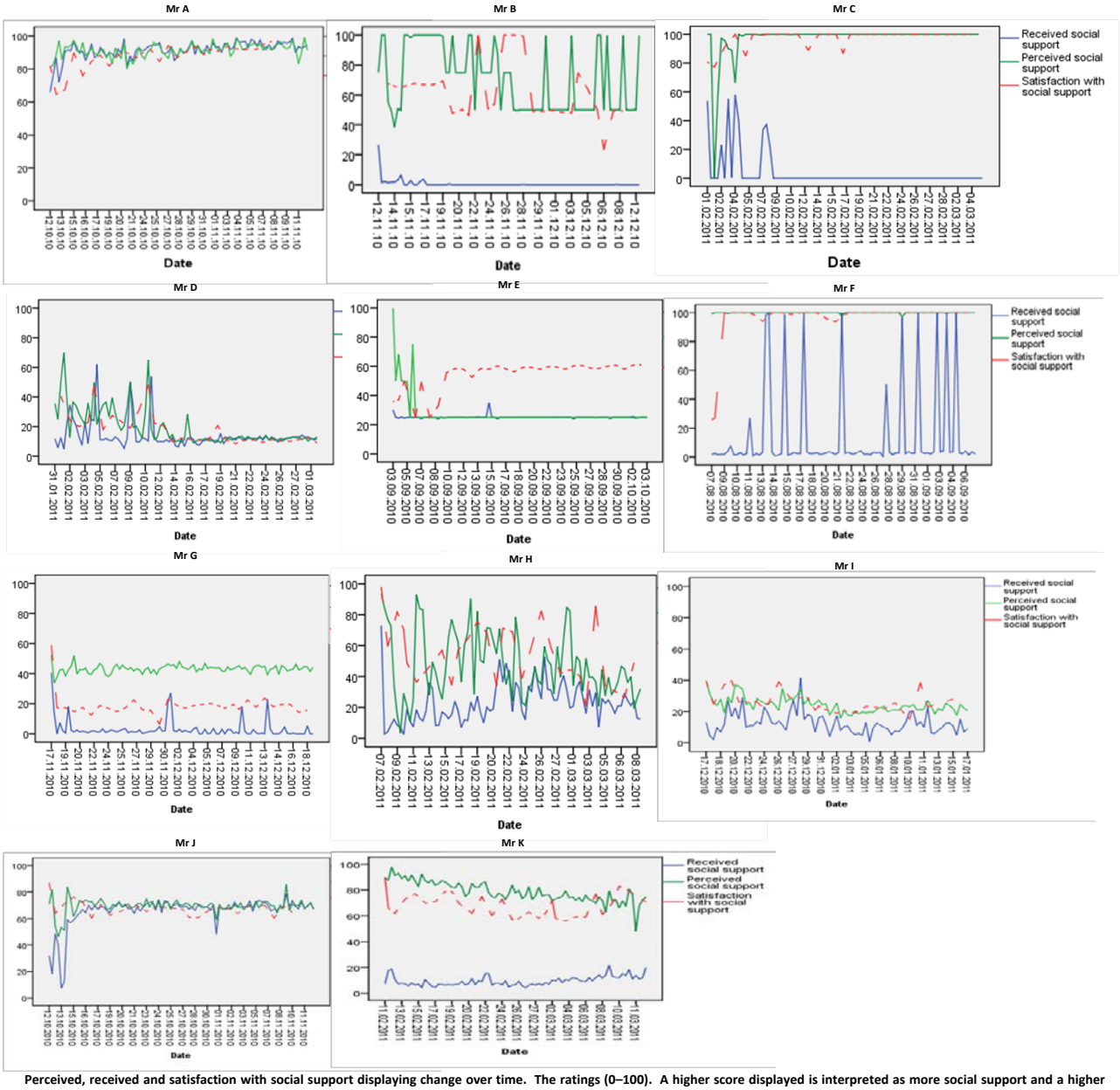


Figure 2 Overview of study participants

Supplementary Information



Perceived, received and satisfaction with social support displaying change over time. The ratings (0–100). A higher score displayed is interpreted as more social support and a higher level of satisfaction.

Figure 1S Perceived, received and satisfaction with social support displaying change over time

Statistical Analysis: Mr A

Table 2S Mr A: Positive coping and negative affect partially mediated by perceived social support

Step and variable	B	SE B	β	R^2
Step 1 (path C)				
Constant	10.372	1.736		
Outcome: SQRT negative affect				
Predictor: Positive coping	-0.082***	0.019	-0.419***	0.175
Step 2 (Path A)				
Constant	53.968	8.084		
Outcome: Perceived social support				
Predictor: Positive coping	0.411***	0.089	0.447***	0.200
Step 3 (path b and c')				
Constant	13.761	2.058		
Outcome: SQRT Negative affect				
Mediator: Perceived social support (path b)	-0.063**	0.022	-0.297**	
Predictor: Positive coping	-0.056**	0.020	-0.286**	0.246

*P<0.05, **P<0.01, P<0.001, n=88

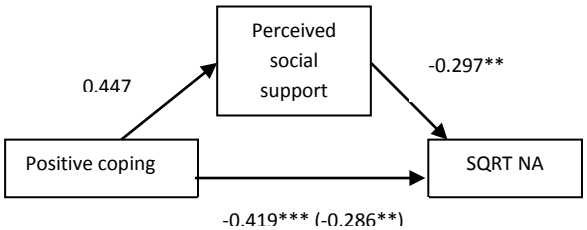


Figure 3S Beta weights for the relationship between positive coping and SQRT NA partially mediated by perceived social support for Mr A

The beta weights for positive coping and SQRT NA controlling for perceived social support are in the parentheses *P<0.05, **P<0.01, ***P<0.001

Statistical Analysis: Mr B

Table 3S Mr B Moderation: Positive coping and negative affect moderated by received social support

Step and variable	B	SE B	β	R^2	Adj R^2
Step 1					
Constant	0.159	0.194			
Z score positive coping $_{PreW\ 1}$	-0.732**	0.186**	-0.402**		
Z score received support	1.486*	0.576*	0.264*	0.197**	0.177**
Step 2					
Constant	-0.072	0.199			
Z score positive coping $_{PreW\ 1}$	-0.354	0.215	-0.194		
Z score received support	0.553	0.624	0.098		
Z score positive coping $_{PreW\ 1}$ X Z score received support	2.525**	0.814**	0.384**	0.285**	0.258**

Dependant variable negative affect $_{preW\ 2}$ *p<0.05, **P<0.01 n=83

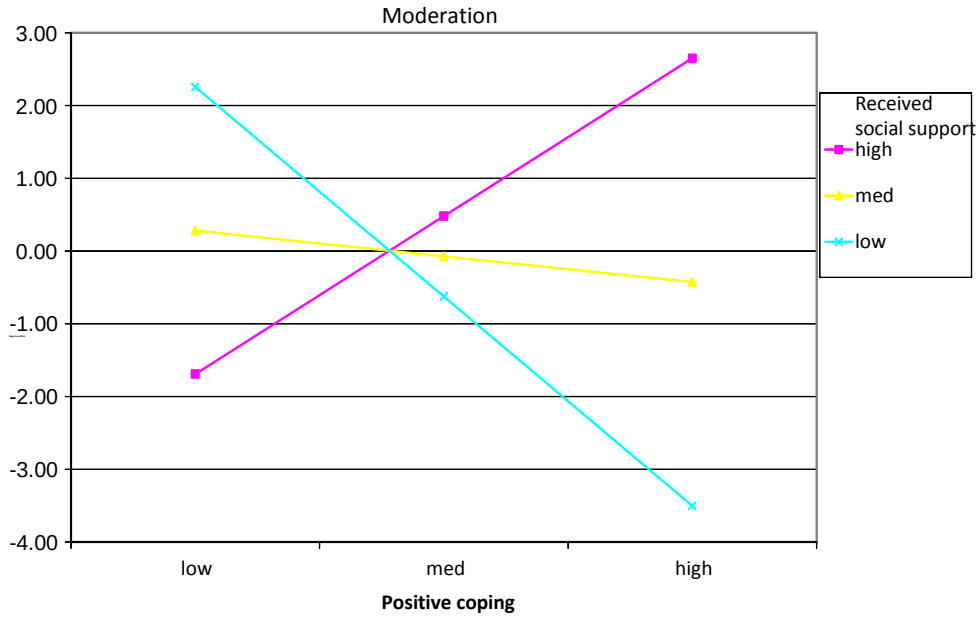


Figure4S Mr B: Positive coping and negative affect moderated by received social support

Statistical Analysis: Mr C

Table 4S Mr C: Results moderation of negative coping and received social support on negative affect

Step and variable	B	SE B	β	R^2	Adj R^2
Step 1					
Constant	3.347	0.076			
Z score negative coping	0.332**	0.085**	0.422**		
Z score received support $_{PreW\ 1}$	0.044	0.081	0.059	0.197**	0.176**
Step 2					
Constant	3.309	0.076			
Z score negative coping	0.278**	0.086**	0.354**		
Z score received support $_{PreW\ 1}$	-0.122	0.105	-0.163		
Z score negative coping X Z score received support $_{PreW\ 1}$	0.133*	0.056*	0.346*	0.253**	0.223**

Dependent variable square root negative affect $_{(preW\ lag\ 1)}$*p<0.05, **P<0.01, n=79

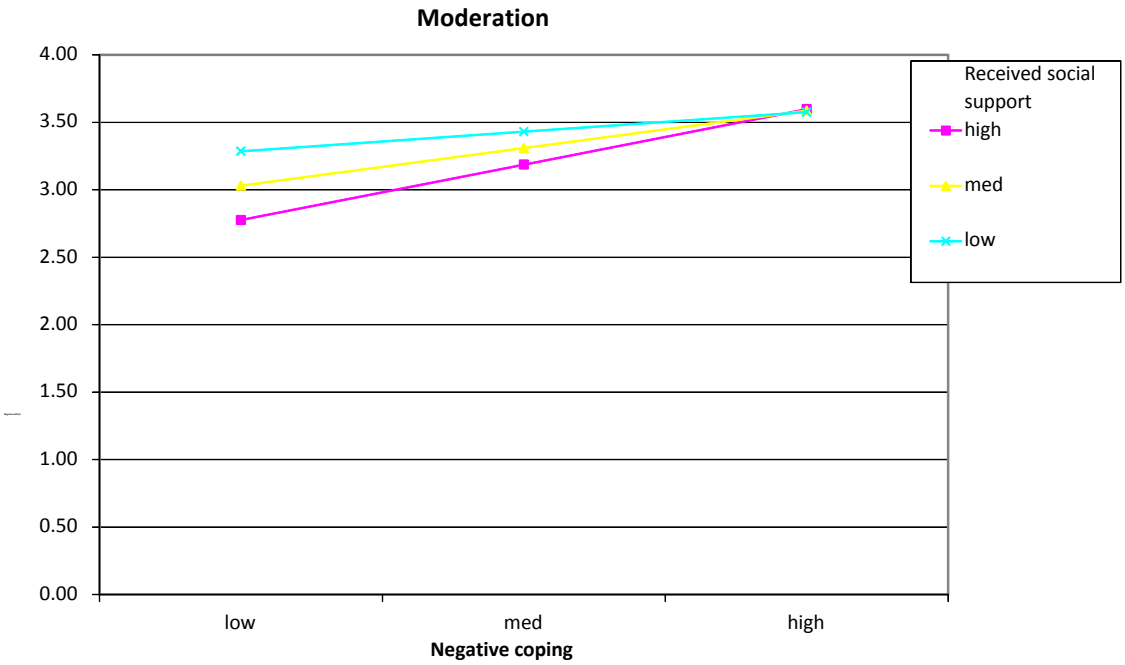


Figure 5S Mr C: Negative coping and negative affect moderated by received social support

Statistical Analysis: Mr F

Table 5S Mr F: Negative coping and negative affect moderated by received social support

Step and variable	B	SE B	β	R^2	Adj R^2
Step 1					
Constant	2.109	0.084			
Z score negative coping $_{(log)}$	0.193*	0.085*	0.254*		
Z score received support	-0.091	0.086	-0.188	0.087*	0.061*
Step 2					
Constant	2.085	0.082			
Z score negative coping $_{(log)}$	0.412**	0.123**	0.542**		
Z score received support	-0.101	0.083	-0.132		
Z score negative coping $_{(log)}$ X Z score received support	-0.136*	0.057*	-0.388**	0.153*	0.119*

Dependant variable negative affect $_{(log)}$ *p<0.05, **p<0.01 n=78

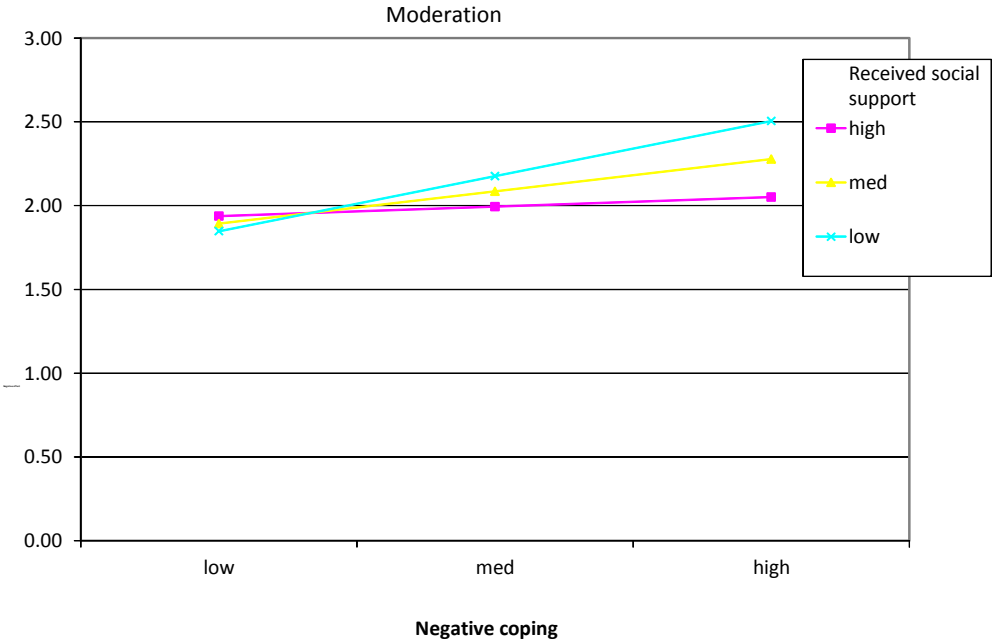


Figure 6S Mr F: Negative coping $_{(log)}$ and negative affect $_{(log)}$ moderated by received social support

Table 6S Mr F: Negative coping $_{(log)}$ and negative affect $_{(log)}$ moderated by perceived social support

Step and variable	B	SE B	β	R^2	Adj R^2
Step 1					
Constant	2.103	0.083			
Z score negative coping $_{(log)}$	0.196*	0.093*	0.254*		
Z score perceived support	0.019	0.093	0.024	0.087**	0.063**
Step 2					
Constant	2.034	0.083			
Z score negative coping $_{(log)}$	0.282*	0.095*	0.367*		
Z score perceived support	0.397*	0.166*	0.516*		
Z score negative coping $_{(log)}$ X Z score perceived support	0.150**	0.055**	0.619**	0.153**	0.119**

Dependant variable negative affect $_{(log)}$ *p<0.05, **p<0.01, n=78

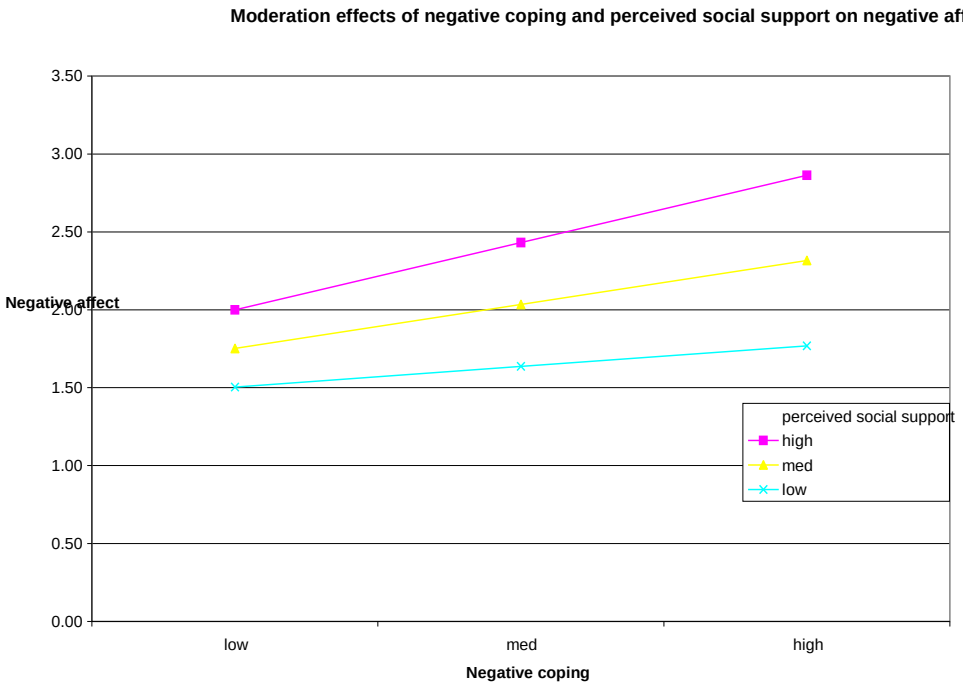


Figure 7S Mr F: Negative coping and negative affect moderated by perceived social support

Statistical Analysis: Mr H

Table 7S Mr H: Positive coping and negative affect partially mediated by perceived social support

Step and variable	B	SE B	β	R^2
Step 1 (path C)				
Constant	52.413	19.329		
Outcome: Negative affect (preW lag1)				
Predictor: Positive coping	-0.582**	0.214	-0.278**	0.077
Step 2 (Path A)				
Constant	-65.317	25.272		
Outcome: Perceived social support(preW lag1)				
Predictor: Positive coping	0.725*	0.280*	0.266*	0.071
Step 3 (path b and c')				
Constant	42.059	19.727		
Outcome: Negative affect (preW lag1)				
Mediator: Perceived social support (preWlag1) (path b)	-0.159*	0.080	-0.207*	
Predictor: Positive coping	-0.467*	0.218	-0.223*	0.117

*P<0.05, **P<0.01, P<0.001, n=88

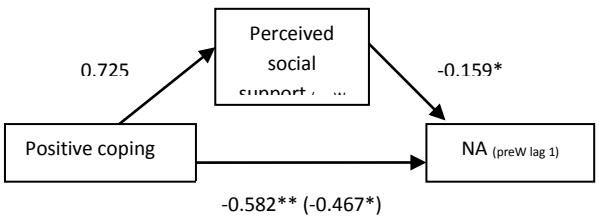


Figure 8S Beta weights for the relationship between positive coping and SQRT NA partially mediated by perceived social support for Mr H.

The beta weights for positive coping and SQRT NA controlling for perceived social support are in the parentheses *P<0.05, **P<0.01, ***P<0.001

Table 8S Mr H: Negative coping and negative affect partially mediated by perceived social support

Step and variable	B	SE B	β	R^2
Step 1 (path C)				
Constant	-13.253	4.247		
Outcome: Negative affect (PreW lag 1)				
Predictor: Negative coping	0.441**	0.134**	0.331**	0.110**
Step 2 (Path A)				
Constant	10.272	5.750		
Outcome: Perceived social support (PreW lag 1)				
Predictor: Negative coping	-0.181	-0.197	0.039	0.079
Step 3 (path b and c')				
Constant	-11.607	4.245		
Outcome: Negative affect (PreW lag 1)				
Mediator: Perceived social support (PreW lag 1) (path b)	-0.160*	0.077*	-0.209*	
Predictor: Negative coping	0.386**	0.134**	0.290**	0.152*

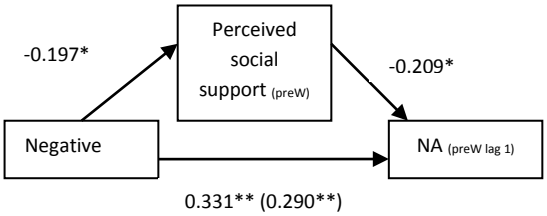


Figure9S Beta weights for the relationship between positive coping and SQRT NA partially mediated by perceived social support for Mr H.

The beta weights for positive coping and SQRT NA controlling for perceived social support are in the parentheses *P<0.05, **P<0.01, ***P<0.001